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REACTOR SCHEDULE

The first irradiation test was conducted in the General Atomics, Triga Mark F, pulse reactor during April 3rd-5th. The present reactor schedule, for the remaining five irradiations, are:

KEWB	May 16-17 incl.
GTR	June 10-14
Sandia	Aug. 6-9
Ford) CP-5)	Oct. 15-29

These dates are firm with the exception of Ford and CP-5, with whom subcontract negotiations are still in progress.

TEST SPECIMENS AND EQUIPMENT

All test specimens, required for the remaining five irradiations, have been fabricated. These (Figure 1) are being operationally tested and characterized as time permits. Test chambers and test equipment (Figure 2) are complete. Materials still required, and being procured, are additional dosimetry foils, and 50 feet of polyolefin tubing. This tubing is used to provide a water proof access between one of the test chambers and the outside world for use in the FORD swimming pool reactor.

PULSE REACTOR REQUIREMENTS

As was indicated in the February and March progress reports, it appeared doubtful that the three amplifier test specimens would exhibit any significant degradation with exposure to the nuclear environment of 10^{15} nv_et. The

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Figure 1. Test Specimens

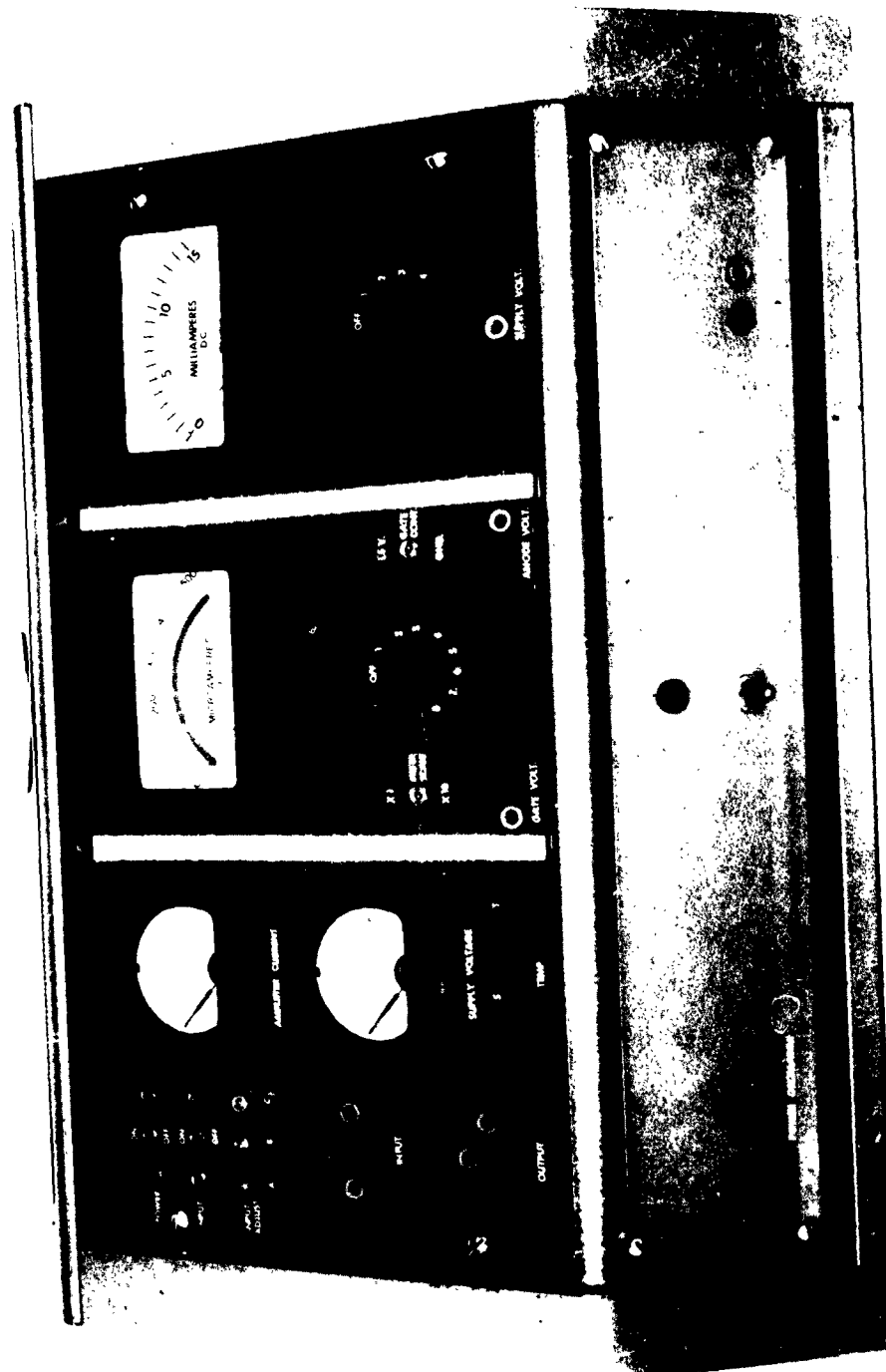


Figure 2. Test Console

results of the first pulse irradiation has verified this conclusion. Inasmuch as a determination of the effect of neutron and gamma spectra on system performance is thus not practical for the pulse environment, in the latter two pulse irradiations such a high level exposure will not be attempted, particularly for SPRF where an excessively high number of bursts would be required. A deviation to the exhibit specification has been requested. In the last two pulse irradiations, observation of transient and temporary effects will be the primary consideration.

TEST RESULTS

The results of the first pulse irradiation, at TRIGA MARK F, are presented in tabular form in Tables I through III, while the performance of the gyro preamplifiers during burst #1, 30, and 70 are shown photographically in the latter pages, numbered by burst.

Table I illustrates pre and post irradiation characteristics of the amplifiers in a 25°C ambient air environment. Technical considerations made it not feasible to measure the amplifier open loop gains, while in the reactor, or in their test chamber, which negated testing at 55°C. It should be noted that I_c (collector current) is presented in this table, whereas I_t (total amplifier current) is presented in Table III, due to the afore noted considerations. The open loop gains of all amplifiers decreased significantly. Transistor data (see Table II) indicated that this was not a result of Beta degradation. Further investigation indicated that the tuned transformers did not appear to shift in resonant frequency (5KC = 100%, 4 & 6KC = 70% voltage) but that a lowering of transformer Q might have occurred. This parameter will be reported on, in greater detail, after the next pulse irradiations.

Table II presents pre and post irradiation data on the transistor used in each amplifier. It should be noted that I_{CBO} (or BV_{CBO}) was not significantly affected by the exposure. Emitter to base contact potential was likewise negligibly affected. The variation in pre to post Beta is not

TABLE I
AMPLIFIER DATA (+25°C) PRE-POST TRIGA MARK F.

AMP. S/N	OPEN LOOP GAIN		CLOSED LOOP GAIN		I _c (ma)	
	PRE	POST	PRE	POST	PRE	POST
1A	200	154	8.0	8.0	4.0	4.1
1B	200	166	8.0	8.0	4.0	4.2
1C	200	135	8.0	7.8	4.0	4.0

NOTE: POST DATA MEASURED 26 DAYS AFTER LAST BURST.

TABLE II
TRANSISTOR DATA (+25°C) PRE-POST TRIGA MARK F.

IN AMPLIFIER S/N	DC BETA@5ma V _{CE} = IV		BV _{ceo} @ 100 μ a/10 ma		BV _{cbo} @ 100 μ a		BV _{ebo} @ 100 μ a	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST
1A	8	8.3	30/20	26/20	30	27	0.46	.46
1B	8	8.5	27/20	23/19	27	24	0.48	.47
1C	8	7.4	30/20	25/20	30	26	0.50	.49

NOTE: POST DATA MEASURED 26 DAYS AFTER LAST BURST.

thought to be caused by instrument reading error, and being within $\sim 5\%$ does not permit any conclusion to be drawn.

Table III tabularly presents baseline and post data characteristics of each amplifier after selected bursts. The bursts selected for this table are illustrative of data secured up to the burst noted. I_t represents total amplifier current (i. e. collector, biasing network, and base). The calculated neutron environment shown, as derived from a prior fission and standard foil environment run, is compatible with the Litton measured values of $nv_o t$, $nv_e t$, and $nv_f t (S)$.

The tabular data and oscilloscope photographs for burst #1, 30, and 70 were selected to illustrate amplifier performance at start, midpoint, and terminal exposure. These are typical of all data secured; the use of other photographs would be redundant.

It should be noted that at no time were any transients observed on the input to the amplifiers. Hence, shortly after the start of the test the display mode was shifted to show the radiation burst compared to the amplifier output, rather than amplifier input and output signals.

For burst #1, transients may be seen on the amplifier outputs 30 ms after trace start. The transients are particularly noticeable for amplifiers S/N 1A and 2A (Figures 1 and 2). It may be noted from these photographs that the output amplitude was never influenced by the burst except to a very minor extent, and it appears that the transient would impair system operation to a negligible extent. The pulse duration precluded any oscilloscope setting which would illustrate or delineate exactly what was happening to the waveform. In addition it should be noted that the inputs of the two channels were utilized in a chopped mode. The alternate mode of input operation is unsatisfactory in that the second trace to be swept would be past the duration of the burst. The sweep speed required, plus the chopped input mode, prevented securing a sinusoidal output pattern for photography.

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Condition	Closed Loop Gain ¹			I _t (ma)			Air Temp. °C	E _n < 0.48 ev			E _n > 0.48 ev		
	A	B	C	A	B	C		nv _o	nv _o t	Acc. nv _o t	nv _e	nv _e t	Acc. r
Baseline	9.2	9	9	7.2	7.2	7.0	56	—	—	—	—	—	—
After burst No. 1	9.4	9	9	7.2	7.2	7.0	55	2.99(14)	3.59(12)	3.59(12)	2.43(15)	2.81(13)	2.81(
No. 50	9.4	9	9	7.1	7.1	7.0	58	2.99(14)	3.53(12)	1.74(14)	2.34(15)	2.76(13)	1.56(
No. 60	9.4	9	8.8	7.1	7.1	7.0	58	2.99(14)	3.59(12)	2.10(14)	2.33(15)	2.81(13)	1.64(
No. 70	9.2	9	8.8	7.1	7.1	7.0	54	2.99(14)	3.45(12)	2.45(14)	2.34(15)	2.70(13)	1.91(

- NOTES:
1. All measurements based on 1 volt P-P input at 5 Kc.
 2. Calculated from reactor spectrum.
 3. Ergs/gm(C) accumulated, R/sec per burst.

TABLE III

GYRO PREAMPLIFIERS S/N 1A, 1B, 1C
PERFORMANCE IN TRIGA MARK F PULSE REACTOR

c. nv _o t	E _n > 0.48 ev			E _n > 10 Kev (Pu) ²			E _n > 0.6 Mev (Np) ²			E _n > 1.5 Mev (U) ²			E _n
	nv _e	nv _e t	Acc. nv _e t	nv _f	nv _f t	Acc. nv _f t	nv _f	nv _f t	Acc. nv _f t	nv _f	nv _f t	Acc. nv _f t	nv _f
—	—	—	—	—	—	—	—	—	—	—	—	—	—
.59(12)	2.43(15)	2.81(13)	2.81(13)	1.24(15)	1.49(13)	1.49(13)	8.14(14)	9.83(12)	9.83(12)	5.30(14)	6.37(12)	6.37(12)	2.12(14)
.74(14)	2.34(15)	2.76(13)	1.36(15)	1.24(15)	1.47(13)	7.22(14)	8.13(14)	9.58(12)	4.6(14)	5.30(14)	6.26(12)	3.08(14)	2.12(14)
.10(14)	2.33(15)	2.81(13)	1.64(15)	1.24(15)	1.49(13)	8.68(14)	8.18(14)	9.83(12)	5.73(14)	5.30(14)	6.37(12)	3.71(14)	2.11(14)
.45(14)	2.34(15)	2.70(13)	1.91(15)	1.25(15)	1.44(13)	1.02(15)	8.22(14)	9.48(12)	6.69(14)	5.32(14)	6.13(12)	4.33(14)	2.12(14)

1A, 1B, 1C
PULSE REACTOR

2	$E_n > 0.6 \text{ Mev (Np)}^2$			$E_n > 1.5 \text{ Mev (U)}^2$			$E_n > 2.9 \text{ Mev (S)}$			Gamma ³	
cc. $nv_f t$	nv_f	$nv_f t$	Acc. $nv_f t$	nv_f	$nv_f t$	Acc. $nv_f t$	nv_f	$nv_f t$	Acc. $nv_f t$	ergs/gm(C)	R/sec
.49(13)	8.14(14)	9.83(12)	9.83(12)	5.30(14)	6.37(12)	6.37(12)	2.12(14)	2.54(12)	2.54(12)	5.1×10^6	4.8×10^6
.22(14)	8.13(14)	9.58(12)	4.76(14)	5.30(14)	6.26(12)	3.08(14)	2.12(14)	2.50(12)	1.23(14)	2.5×10^8	4.5×10^6
.68(14)	8.18(14)	9.83(12)	5.73(14)	5.30(14)	6.37(12)	3.71(14)	2.11(14)	2.54(12)	1.48(14)	3.0×10^8	4.4×10^6
.02(15)	8.22(14)	9.48(12)	6.69(14)	5.32(14)	6.13(12)	4.33(14)	2.12(14)	2.54(12)	1.73(14)	3.5×10^8	4.6×10^6

It should be noted that after burst #1, the amplifier output transients reduced in magnitude with each succeeding burst; by #11 were inconsequential.

CORRELATION EXPERIMENT

Inasmuch as permanent damage was not expected in the pulse irradiations and it was felt that this would limit the extent of the spectra-damage comparison, Litton Industries at negligible expense to the test program arranged to include 8 field effect transistors in each irradiation. The degradation of these components in both pulse and steady state reactors will be correlated against permanent degradation in the gyro preamplifiers which will be obtained in the steady state environments by exceeding the 10^{15} $Nv_e t$ minimum exposure specification. The first pulse irradiation has shown significant degradation of the field effect transistors, averaging about 0.7 gm/gm₀ at approximately 4×10^{14} $nv_e t$. Data on this series of correlation tests will be elaborated upon in future progress reports.

NEUTRON EXPOSURE

It was felt that, and as per exhibit specification requirements, as full a delineation of the neutron spectra as obtainable should be secured within practical constraints of techniques and funding. Where fission foil spectra determinations have been made, and are compatible with the Litton test configuration and installation, these are used. Litton dosimetry (Au bare and Cd covered; sulfur) are used to determine that at these energy points correlation is secured with the previous spectral data which then allows calculation of exposure at the fission foil energies. At facilities not characterized by fission foils, or where such data is not applicable, such dosimetry will be utilized where technically feasible.

Where the reactor spectrum does not have a $1/E$ dependency in the resonance region (1 ev to 1 Kev) this negates epicadmium flux ($nv_e t$) determination. The determination of $nv_o t$ and $nv_t t$ is not affected. Inasmuch as most reactors do not have a $1/E$ dependency in the resonance

region, the presentation of a n_{eff} or cadmium ratio is allowable only on the basis of its usefulness for comparison, representing only an "apparent" value and not an accurate value. This is particularly true of reactors where the Rcd ratio is low, indicating a high degree of thermal flux shielding or effects of nearby moderators. This situation exists at TRIGA, KEWB and most of the other reactors employed in the program, but does not conclude a comparison of the effect of neutron spectra vs amplifier damage. Further discussion of these parameters will be presented later in the program.

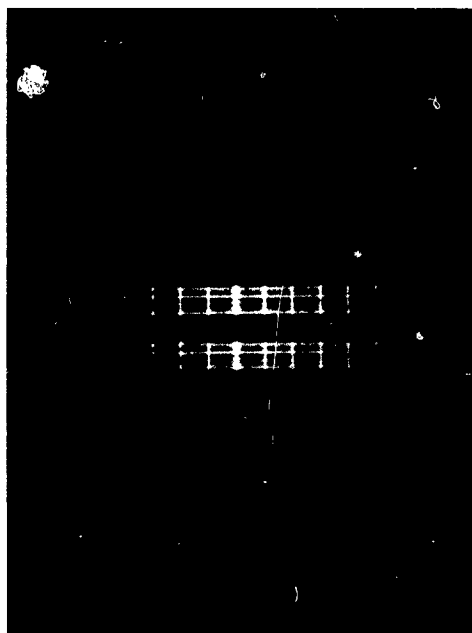


FIGURE 1



FIGURE 2



FIGURE 3

TRIGA MARK F
PULSE IRRADIATION NO. 1

DATE: April 3, 1963 TIME: 1422
AMBIENT AIR TEMPERATURE: 56°C
ZERO AND ELAPSED TIME: Left (Start of Trace) to Right.

FIGURE 1 GYRO PREAMPLIFIER S/N 1A
SWEEP: 10 msec/cm
AC INPUT: Upper Trace, 1.0 V/cm
AC OUTPUT: Lower Trace, 10 V/cm

FIGURE 2 GYRO PREAMPLIFIER S/N 1B
SWEEP: 10 msec/cm
AC INPUT: Upper Trace, 1.0 V/cm
AC OUTPUT: Lower Trace, 10 V/cm

FIGURE 3 GYRO PREAMPLIFIER S/N 1C
SWEEP: 10 msec/cm
AC INPUT: Upper Trace, 1.0 V/cm
AC OUTPUT: Lower Trace, 10 V/cm

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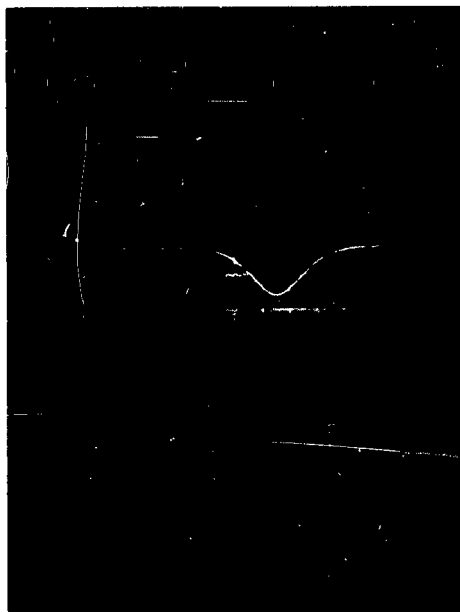


FIGURE 1

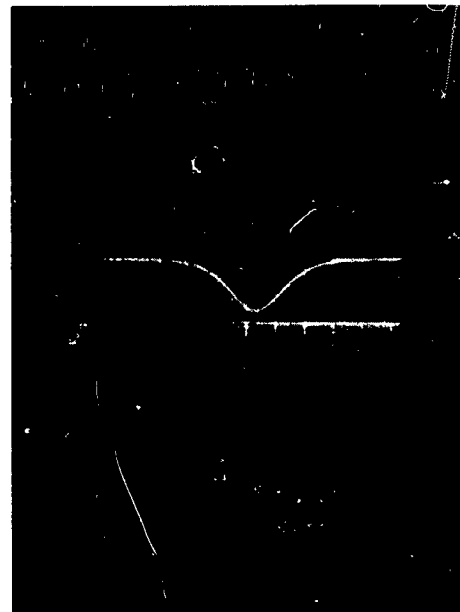


FIGURE 2



FIGURE 3

TRIGA MARK F
PULSE IRRADIATION NO. 70

DATE: April 4, 1963 TIME: 1552
AMBIENT AIR TEMPERATURE: 55°C
ZERO AND ELAPSED TIME: Left (Start of Trace) to Right.

FIGURE 1 GYRO PREAMPLIFIER S/N 1A
SWEEP: 5 msec/cm
RADIATION DETECTOR: Upper Trace 2.0 V/cm
AC OUTPUT: Lower Trace 5.0 V/cm

FIGURE 2

FIGURE 2 GYRO PREAMPLIFIER S/N 1B
SWEEP: 5 msec/cm
RADIATION DETECTOR: Upper Trace 2.0 V/cm
AC OUTPUT: Lower Trace 5.0 V/cm

FIGURE 3 GYRO PREAMPLIFIER S/N 1C
SWEEP: 5 msec/cm
RADIATION DETECTOR: Upper Trace 2.0 V/cm
AC OUTPUT: Lower Trace 5.0 V/cm

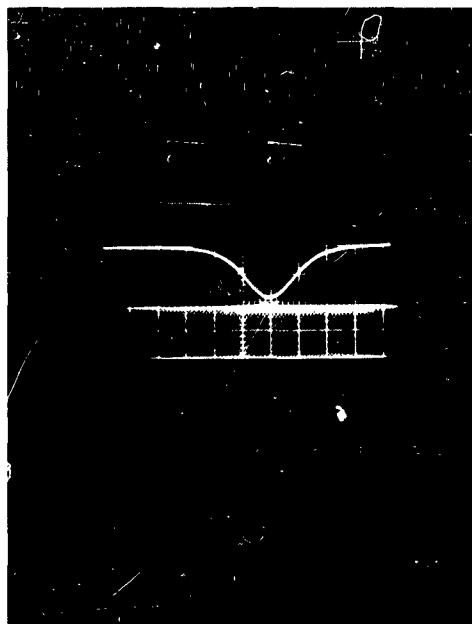


FIGURE 1

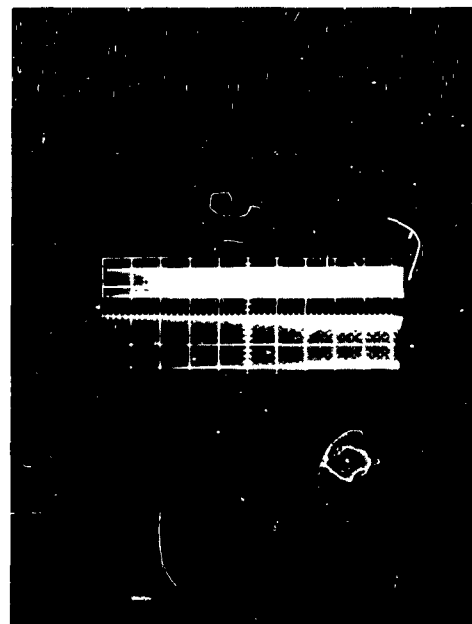


FIGURE 2

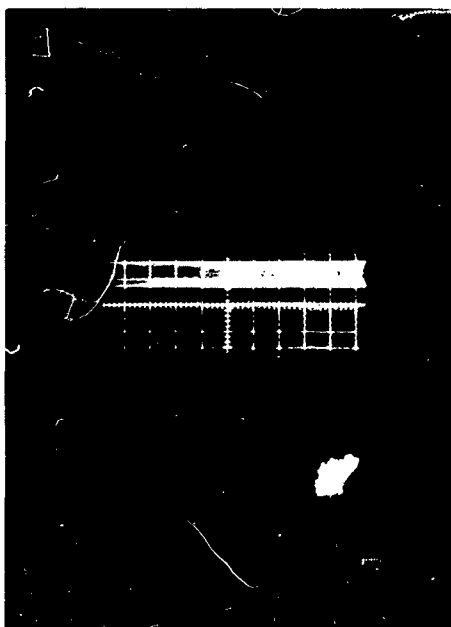


FIGURE 3

TRIGA MARK F
PULSE IRRADIATION NO. 30

DATE: April 4, 1963 TIME: 1050
AMBIENT AIR TEMPERATURE: 52°C
ZERO AND ELAPSED TIME: Left (Start of Trace) to Right.

FIGURE 1 GYRO PREAMPLIFIER S/N 1A
SWEEP: 5 msec/cm
RADIATION DETECTOR: Upper Trace 2.0 V/cm
AC OUTPUT: Lower Trace 5.0 V/cm

FIGURE 2 GYRO PREAMPLIFIER S/N 1B
SWEEP: 5 msec/cm
AC INPUT: Upper Trace 1.0 V/cm
AC OUTPUT: Lower Trace 5.0 V/cm

FIGURE 3 GYRO PREAMPLIFIER S/N 1C
SWEEP: 5 msec/cm
AC INPUT: Upper Trace 1.0 V/cm
AC OUTPUT: Lower Trace 5.0 V/cm